MBA GlobalNet Consulting Partners

Assessing the Commercial Potential of Lawrence Livermore National Lab's Prototype Hand-held Gas Chromatograph

Summary Assessment

February 2002

- The purpose of this document is to provide information regarding MBA GlobalNet's assessment of the commercial potential of Lawrence Livermore National Lab's (LLNL's) Prototype Hand-held Gas Chromatograph
- This information may be useful to those parties interested in licensing the patents, and/or further developing the technology for specific market applications, relevant to LLNL's Prototype Hand-held Gas Chromatograph
- Please direct all questions related to this Summary Assessment and/or the Venture Development services (technology assessments, business planning, interim management, and advisory board) of MBA GlobalNet to the following:

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Technology Description

•Lawrence Livermore National Lab ("LLNL") has developed a prototype, hand-held gas chromatograph which is highly sensitive, miniature, low -powered, self-contained, extremely fast, and lightweight:

- The unit is a small, hand-held self-contained device including carrier gas, injector system, column, injector and column heaters, detectors, computer and software in an eight-pound package about the size of a typical laptop computer suitable for field use.
- The unit has a linear output and demonstrates good separation. The system needs only a few minutes to warm up and requires standardization only once a day.
- Sample turnaround time (from injection to final results) is less than two minutes for light hydrocarbon mixtures. The unit may be equipped with an auto-sampling sniffer and may be left in a hostile or sealed-off environment until equilibrium is reached and later recovered with results ready.
- Columns used in the prototype to date: DB-1, DB-5, DB-54, and DB-wax. Column operating temperature range is 25^{O} to 250^{O} Celsius. Injector heater operates from 25^{O} to 150^{O} Celcius.
- The carrier gas is a self-contained refillable supply of Helium, Hydrogen, or Nitrogen that will last for six hours of continuous sampling. The power supply will last for two hours of continuous sampling before battery replacement or recharging is necessary.
- Accuracy and sensitivity are comparable to traditional bench-based units.
- The unit may be easily used by field technicians with limited training.

Technical Attributes

Attribute	Feature	Benefit
Size	• 8"x5"x3" • 8 lbs in weight	• Easy field use • Extremely portable
Speed	• 30 to 40 second analysis time for most samples	• On the spot analysis • Quick "real time" results
Column Construction	• MEMS-based silicon column • 5 meter length / 100 micron diameter • 25^{o} to 250^{o} Celsius operating temperatures	• Small and portable • Lower sample size requirements • Unit can utilize multiple column types

Technical Attributes (continued)	Attribute	Feature	Benefit
	Power	• Rechargeable battery • Two-hour life at full utilization • Low consumption	Batteries can be replaced easily and quickly in the field allowing continued unlimited use.
	Sensitivity	• Accuracy to 1 ppm with thermal conductivity detector / 35 ppb with glow discharge detector	Laboratory scale accuracy for many applications. Highly reproducible with minimal user training.
	Sample Throughput	• Gas and liquid samples • Up to 30 samples per hour • 1-2 micro liter injection volume	Unit recycle time for many applications is two minutes or less. The GC also has available an auto-sampling sniffer for free-standing analysis of air samples.
	Completeness & Ruggedness	• Accurate results demonstrated over a wide range of samples	Prototype unit has been in operation for over two years without replacement of any major components.
	Analytical Versatility	• Analyzed many chemical compounds within the C3 to C30 range, including C3 to C12 mixture, DMMP, DIMP, Mustard Gas, SF6, benzene, Methyl-benzene, chloro-benzene, methyl-xylene, Ortho-xylene, styrene, and others	Covers most persistent environmental toxins and bio-accumulative toxins. May have applications in pharmaceutical and medical analysis.
	Deployment	• Quick set up time (approximately two minutes) • Can be easily used almost anywhere	Unit can be left in hostile environment with an auto-sampling sniffer to be recovered later with plots / results ready to interpret.

Competitive Position

Competing Technology	Description	• Applications	Advantages	Disadvantages
Flame Ionization Detector (FID)	Gas is burned in a hydrogen flame. The positive ions are collected at electrode, and the resulting current measured.	• Can measure organic compounds • Stable environment, requiring good sensitivity	• FID is highly sensitive • Linear over many orders of magnitude	• Very complex instruments • Requires hydrogen source and a stable environment • Not very suitable for a portable unit
Photo Ionization Detector (PID)	Ultraviolet light ionizes the sample gas, ions produce detectable current.	• Field use • Environmental testing	• Can detect a wide range of volatile organic compounds (“VOCs”)	• Nonselective below ionization potential of lamp • UV lamps are expensive
Electromechanical Sensors	Gas diffuses into sensor and reacts with sensing electrode to cause current flow which is measured.	• Repetitive applications testing for the same presence • Can detect O2 ,CO, NO2, NO, H2S, SO2, NH3, HCL, HCN, CL2 and some organic vapors	• Inexpensive	• Not specific to single gas without the use of filters or other methods • Somewhat limited in detection capabilities
GC Portables	Standard GC but portable (weigh generally in excess of 20 to 25 lbs. when all interfaces are attached)	• Field use • Inspections • Manufacturing process monitoring	• Robust, proven unit (vs. MEMS tech) • Complete line of attachments (multiple columns)	• Heavier portable • Slower analysis speed • Consumables required • Some must be used within an enclosure & require power source
All Other Detectors	Various other instruments not considered portables, i.e., are bench-top devices	• Various, depending on unit • Stable environment • Usually requiring external power	• Well established in market (large support base) • Robust	• Heavy (over 25 lbs) • Not highly sensitive • Slower analysis speed • Consumables required

Market Opportunities

Industry	Potential Users	Detection Uses / Applications
Food & Agriculture	• Food processors • Supermarket chains • Food regulatory agencies • Food research organizations (e.g., FDA)	• Food spoilage • Food quality • Pesticide content • Food & Ag research
Law Enforcement	• Federal and State law and drug enforcement agencies	• Alcohol / drugs (breath) • Drugs / contraband
Environmental & Industrial Monitoring	• Federal and State environmental agencies (e.g., EPA) • Facilities management companies • Environmental consulting firms • Manufacturing facilities • Environmental research organizations	• Indoor air pollutants • Outdoor air pollutants • Water & Soil contamination • Auto emissions • Environmental research
Medical / Healthcare	• Physicians • Hospitals • Pharmaceutical companies • Medical and healthcare research organizations	• Illness / wellness
Military & Security	• National militaries and security agencies • Security companies (e.g. airport security)	• Explosives • Chemical and biological warfare

Commercial Potential

Market Applications	4-year Global Mkt. Potential[1]	Required Investment[2]	Market Readiness[3]
Food & Agriculture	$250-500 million	$3-10 million	3
Law Enforcement	$250-500 million[4]	"	2
Environmental & Industrial Monitoring	$50-100 million	"	2
Medical / Healthcare	$150-250 million[5]	"	2
Military & Security	$150-250 million[6]	"	1

1 Based on estimate of incremental units demanded over a four-year period times an assumed price per unit of $15,000
2 Includes cost of Non-recurring Engineering and Certification; excludes cost of licensing and marketing
3 On a scale of 1 to 3 (with 1 being most ready), the market's readiness to adopt this new technology, i.e., to abandon current methods given current regulatory and other factors
4 Includes corporate drug testing
5 Based only on alcohol / drug detection in hospital emergency rooms
6 Based not on estimated units demanded, rather, recent US government funding of homeland security initiatives

Potential Licensees of LLNL HHGC Patents

1. Gas Chromatograph Manufacturers / Distributors
   - Tier 1
   - Tier 2
2. Related Instrument Manufacturers / Distributors
   - Tier 1
   - Tier 2
3. MEMS-based Device Manufacturers / Distributors
4. Major Semiconductor Manufacturers
5. Other Semiconductor Manufacturers
6. Consulting Firms
   - Environmental
   - Other

Alternative Business Models

• **Revenue Model**	**Potential Licensees (see table to left)**
• Sell Device	1 and 2
• License Component(s)	
• Column	1 and 2
• Heater	1 and 2
• Detector	1 and 2
• MEMS Manufacturing Process	3, 4, and 5
• Service Provider	6

Benefits & Obstacles for Licensees

Licensee	Potential Benefits	Potential Obstacles
1. GC Mfgers / Distributors	• For Tier 2, increased market share	• Cannibalization: devices and consumables • "Not invented here" syndrome • MEMS manufacturing inexperience
2. Related Instrument Mfgers / Distributors	• New revenue source • Economies of scope • Economies of scale	• GC inexperience
3. MEMS-based Device Mfgers / Distributors	• New revenue source • Economies of scope • Economies of scale • Increased market share	• GC inexperience • Strategic fit
4. Major Semiconductor Mfgers	• New revenue source • Economies of scope	• GC inexperience • Strategic Fit
5. Other Semiconductor Mfgers	• New revenue source • Economies of scope	• GC inexperience

6. Consulting Firms	• For Environmental firms, increased market share
	• For other firms,
	  - New revenue source
	  - Economies of scope
		• Cannibalization (for those firms with proprietary technology)
		• Inexperience with other detection fields

Assessment Team

MBA GlobalNet Team

Subject Matter Experts

- Jeffrey Bunin, CEO of Bunin Management Advisors, LLC and former Director of Planning at Matheson-Trigas, Inc., a world leader in the manufacture and distribution of high purity chemical gases and advanced monitoring equipment. MBA from Rutgers University Graduate School of Management and BE in Chemical Engineering
- Robert Chiozzi, member of Maine Technology Institute which works with management of and principal investors in IT, biotechnology, and composite materials sectors. MBA from University of Southern Maine and BS in Biology.
- Michael Crill, CFO and Board Member of Atlas Consulting which provides leadership to early phase technology companies. MBA from Duke University (Fuqua) and BS in Finance.

Consultants

- Gary Bonie, Senior Embedded Systems Software Engineer with MBA from UCLA and BS in Electrical Engineering
- Jim Booher, Strategy and Business Re-engineering specialist with MBA from University of Georgia and BS in Business Administration
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- Tom Kellerman, Strategy and Market Analysis specialist with MBA from The Wharton School and BS in Mechanical Engineering
- Courtney Wood, Manager of MBA GlobalNet team and former co-founder of and Chief Strategist for Cap Gemini Ernst & Young's Center for Enterprise Creation (a technology-based business "incubator") with MBA from Columbia Business School and BA in Economics

External Subject Matter Experts

- Hugh Goldsmith, President, SRI Instruments, Torrence, CA (manufacturer of gas and liquid chromatographs and data systems)
- Lloyd Kent, Business Manager, Matheson-Trigas, Inc., Parspippany, NY
- Dr. Ted Labuzza, Morse Alumni Distinguished Professor of Food Science and Engineering, Department of Food Science & Nutrition, University of Minnesota (St. Paul, MN)

Services

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